oscillatory, and, therefore, account must be taken of the pressures involved in producing changes of motion, in consequence of which the pressures differ from those which would exist at any instant if the motion were steady. These pressures, which I have called the "$d\phi/dt$ pressures," after the term which produces them in the hydrodynamical equation, are completely modified in their action when continuous motion is replaced by discontinuous motion, but their effect can only be discussed from general principles. Other points are the effect of the ship's forward motion in increasing the steadying action, and the influence of bilge-keels in modifying pitching and in improving the steering of ships; the two last effects are further simple consequences of the properties of discontinuous motion.

We have seen that the action of bilge-keels in steadying a ship is largely modified by the actions of the sides of the ship, and is much augmented when the keels are placed in a suitable position; and it is interesting to notice how the exigencies of trade, while they have necessitated the removal of keels from the middle line of the ship to the sides, have brought about such a change in the form of the section as to render the new position by far the most effective. In the old pointed-bottomed ship, the central keel was the best, as it not only intercepted the currents flowing round the bottom in each swing from side to side, but also produced a difference of pressure on the two sides whose moment was always opposed to rolling. In the modern flat-bottomed ship of rectangular section a central keel would be unfavourably placed for this purpose, as not only would the water tend to flow in the same direction as that in which the ship is rolling, producing a diminished pressure on the keel, but the differences of pressure on the sides of the ships would have a moment tending to diminish the resistance to rolling. The favourable position now commonly assigned to the bilge-keel is calculated to render its addition to ships of the greatest value in increasing their steadiness. G. H. BRYAN.

THE "ORTHOSTIGMAT" LENS.

A SPECIMEN of the new series of lenses issued under the joint auspices of Messrs. Beck and Steinheil, has been tested and examined by us. The lens is of the rectilinear symmetrical type with two equal combinations, each consisting of three elements. It is by special construction of the surfaces of these components that the remarkable qualities claimed for, and undoubtedly possessed by, the new lens are attained. The great drawback to the best of the old type lenses was the curvature of field, and it is only in recent years that the discovery of the new varieties of glass has made it possible to correct this, and at the same time perfect the corrections for spherical aberration and astigmatism. The result of the process is that each component of the lens is made up of a positive meniscus, with a double convex lens cemented on one side of it and a double concave one on the other. The centre positive lens will consequently have a lower power than the two outer ones.

When it is understood that each of the twelve surfaces involved in the complete lens is worked with such accuracy that an error of 1/40,000th of an inch is inadmissible, the increased price, compared with the old types of lenses, is amply accounted for in the superior product obtained.

We have tested the lens, which is of about $4\frac{3}{4}$ inches solar focus, and are quite satisfied that it fulfils to a high degree of perfection the claims made for it by the makers. Although the lens is listed for $\frac{1}{4}$ plate, the circle of good definition is much larger, and with a stop of $f/16$ excellent definition was obtained over the whole of a $\frac{1}{2}$ plate. The lens at its greatest rapidity works at $f/6\cdot3$, and at this aperture the definition appears very perfect over an area $4\frac{1}{4}$ inches square. The makers call attention to the special attempts they have made to eliminate astigmatism, and it is not until an oblique pencil falls considerably beyond the listed angle that any distortion shows itself. To make this clearer, let the image of the sun, moon, a star, or any distant object, be focussed at the centre of the plate, and then the camera so tilted that the image falls gradually away to the extreme corner. The slightest distortion can be at once recognised in this manner. With the lens in question no distortion was evident until the image was received at an angle of about 30 degrees from the axis, and for another 10 degrees further the resulting astigmatism, although present, was much less than is present closer to the axis in a rectilinear of the ordinary type. So that for an angle of view of over 60° the new lens is practically non-astigmatic at the large aperture $f/6\cdot3$ This will recommend it especially for all process and copying work, where critical definition and speed are primary necessities. A word should be said concerning the focussing with these new lenses. This adjustment must be critical, as an almost imperceptible displacement of the plate will suffice to throw it out of the focal plane sufficiently to destroy the definition, and so create false impressions of the capabilities of the optical system. For all such work, therefore, only perfectly rigid apparatus is permissible.

Another important qualification of the lens is its comparative freedom from chromatic aberration, in virtue of which it will be useful for work connected with colour photography, obviating the laborious and uncertain corrections which are necessary in such work with the ordinary lenses, whose chromatic aberrations are only suppressed for the blue and yellow. Critical tests of this correction have not been possible, but sufficient have been made to show that the outstanding error is small.

On account of their covering power, the smaller sizes will be found excellent for low-power microphotography. The new lenses are obtainable with foci varying from $3\frac{1}{2}$ in. to $23\frac{1}{2}$ in., covering plates from $3\frac{1}{4}$ in. square to 28×24 inches.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The Romanes Lecture will be delivered by Dr. James A. H. Murray on Friday, June 22, upon "The Evolution of English Lexicography."

Sir William Thiselton-Dyer, F.R.S., has been made a permanent elector to the Sherardian Professorship of Botany, in succession to the late Prof. Bartholomew Price.

The Statute instituting Diplomas in Geography has been approved by Convocation, and is to remain in force until October, 1904.

The extensive bequest to the University under Mr. Fortnum's will has made an enlargement of the Ashmolean Museum necessary. The cost is estimated at 1500*l.*, and towards this sum Brasenose College has offered a contribution of 500*l.*

At Merton College there will be an election to a fellowship on October 6, after an examination in Animal Physiology and Animal Morphology. Candidates are requested to inform the Warden by September 10 of their choice between these two subjects, and to submit, if they wish, original papers or memoirs.

At a meeting of the Oxford University Junior Scientific Club, held on Wednesday, June 6, Sir John Burdon Sanderson, F.R.S., gave an account of the method he has been lately employing for producing tetanus in muscle, by means of telephone currents produced by musical sounds, showing how the results bear on the vexed question of the inherent rhythmicality of muscle and nerve-cell. The lecture was illustrated by experiments.

At a meeting of the above club held on Friday, June 15, Mr. T. C. Porter, of Eton College, described the growth of the shadow of the Peak of Teneriffe, as witnessed from the summit of the mountain at sunrise and sunset, and its gradual eclipse by the shadow of the earth. He showed photographs taken at the time, and explained how by means of an ordinary watch and pair of opera glasses a rough value of the diameter of the earth might be deduced.

Mr. A. F. Walden, New College, made a preliminary communication to the club on the theory of labile hydrogen atoms.

CAMBRIDGE.—The researches of Mr. J. C. McLennan on electrical conductivity in gases traversed by kathode rays, and of Mr. R. L. Wills, of St. John's College, on the magnetic properties of iron as influenced by temperature and the presence of other elements, have been approved by the Degree Committee as qualifying for the B.A. degree.

In the Natural Sciences Tripos, which is now the largest of the Honour Examinations, forty men and three women are placed in the first class of Part I. In Part II. fourteen men and no women obtain first-class honours.

At St. John's College the following awards in natural science were made on June 18. Foundation Scholars continued or elected: Lewton-Brain, May, Adams, Ticehurst, Fletcher, Browning, Wakely, Gregory, Williams, Harding, Hepworth,

Pascoe, King, Macalister, Mitchell. Exhibitioners: Crocker, Denham, Simpson, Balls. Hockin Prizeman (for electricity): Browning. Engineering Scholar: Paton.

THE attention of teachers and others engaged in schools is directed to the appeal made by Prof. Karl Pearson in our correspondence columns. Observations of the physical and mental characters of children are required, and measurements of the head, in order to provide material for an investigation of heredity upon which Prof. Pearson is engaged. There should be no difficulty in obtaining the co-operation of masters and mistresses in schools in this work, for the observations and measurements can be made with very little trouble, and they are of as much interest from an educational point of view as they are to biological science.

SCIENTIFIC SERIAL.

Bulletin of the American Mathematical Society, May.—The number opens with four papers read before the Society at the dates annexed: On the geometry of the circle, by Dr. V. Snyder (December 28, 1899); isomorphism between certain systems of single linear groups, by Prof. L. E. Dickson (February 24); the Hessian of the cubic surface ii., by Dr. J. I. Hutchinson (February 24); and note on the group of isomorphisms, by Dr. G. A. Miller (February 24). These papers are short and, in the main, continuations of work previously published by the authors.—Prof. F. S. Woods contributes an interesting sketch of a German translation, by F. Engel, of two articles by Lobachevsky, with the titles "Ueber die Anfangsgründe der Geometrie" and "Neue Anfangsgründe der Geometrie mit einer Vollständigen theorie der Parallellinien." The reviewer's conclusion is that, "while it is remarkable that the solution of a two-thousand-year-old problem should be given almost simultaneously by three men, it should be remembered that these three were not the only mathematicians who had worked upon the problem. More than one had missed the solution by a hair's breadth only; Lobachevsky, Bolyai and Gauss succeeded in finding it."—Other notices are Vogt's "Algebraic solutions of equations," by J. Pierpont; the elements of the differential and integral calculus, based on the work by Nernst and Schönflies (translated by W. A. Young and C. E. Linebarger), by L. E. Dickson; and E. Pascal's "Die Variationsrechnung," by J. K. Whittemore.—University and general mathematical information come into the "Notes" and "New Publications."

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, April 5.—"The Kinetic Theory of Planetary Atmospheres." By Prof. G. H. Bryan, F.R.S.

The application of the kinetic theory to the atmospheres of planets dates from the paper of Waterston, who gave an investigation based on the then only possible assumption of equal velocities for all molecules, an assumption since known as Clausius' law. Of later papers reference is due in especial to Dr. Johnstone Stoney's memoir "Of Atmospheres on Planets and Satellites" (*Trans.* R. Dublin Soc.), in which the test of permanence of a gas in the atmosphere of a planet is made to depend on the ratio of its velocity of mean square to that relative velocity which would enable a suitably projected body to escape from the planet's attraction. If it be admitted, as Dr. Stoney assumes, that helium cannot exist in our atmosphere, it follows that vapour of water cannot exist on Mars.

The author's object has been to investigate the logical conclusions obtained by applying the Boltzmann-Maxwell distribution to the atmospheres of planets. In 1893 calculations were made, having special reference to the absence of atmosphere from the moon, but these took no account of axial rotation. When this cause is taken into account, the distribution of co-ordinates and *relative* velocities of the molecules is found to be the same as if the planet were at rest, and "centrifugal force" applied to the system. The surfaces of equal density are of the forms originally investigated by Edward Roche, of Montpellier, and they cease to be closed surfaces when passing to the outside of the point on the equatorial plane where centrifugal force just balances the planet's attraction. Calling the surface through this point the "critical surface," the density of molecular distribution over this surface must be very small to ensure permanence. The ratio of the density at the planet's surface to the density at the critical surface has been called the "critical density ratio," and the author calculates its logarithm for particular gases at different temperatures on the various planets. The use of this logarithm has the advantage that the calculation can at once be extended to any gas at any temperature.

The high value obtained in the case of helium, considered in reference to the earth, appears to afford abundant proof that if helium existed in our atmosphere it would possess a very high degree of permanence at ordinary temperatures. To test this point further, a calculation is made of the total rate at which molecules would flow across the critical surface, this rate being regarded as a superior limit to the rate at which the planet would lose its atmosphere, since it takes no account of molecules which describe free paths beyond the limit and fall back again. To further exhibit the results in a tangible form, the rate of flow is estimated by the number of years in which the total amount of gas escaping across the critical surface would be equal to the amount of the gas in a layer covering the surface of the planet to the depth of 1 cm. This measure is independent of the actual quantity of the gas under consideration existing in the atmosphere, since, if this quantity be increased, the rate of flow across the critical surface and the amount of gas present in the surface layer 1 cm. thick will be increased in the same proportion.

If a gas of molecular weight 2, such as helium, be supposed to exist in the earth's atmosphere, the loss in question would occupy $3{\cdot}5 \times 10^{36}$ years at $-73°$ C., 3×10^{19} years at 27°, $8{\cdot}4 \times 10^{10}$ years at 127° C., 6×10^{5} years at 227° C., and 222 years at 327° C.

If we halve the absolute temperatures, we have the conditions applicable to hydrogen, the losses in question therefore taking place in $8{\cdot}4 \times 10^{10}$ years at $-73°$ C., 6×10^{5} years at $-23°$ C., and 222 years at 27° C.

For water vapour on Mars, the corresponding results are $1{\cdot}2 \times 10^{33}$ years at $-73°$, $1{\cdot}9 \times 10^{16}$ years at 27°, $2{\cdot}4 \times 10^{9}$ years at 127°, $4{\cdot}3 \times 10^{5}$ years at 227°, and 106 years at 327°.

These figures indicate that helium cannot practically escape from our atmosphere at existing temperatures, nor can vapour of water escape from the atmosphere of Mars. A leakage may, and undoubtedly does, take place, which may appear considerable when estimated by the number of actual molecules escaping, but it is wholly inappreciable relative to the mass of gas left behind.

At a future time it is proposed to examine the corresponding results, based on the hypothesis that the atmosphere of a planet is distributed according to the adiabatic instead of the isothermal law.

"On the Weight of Hydrogen desiccated by Liquid Air." By Lord Rayleigh, F.R.S.

In recent experiments by myself and by others upon the density of hydrogen, the gas has always been dried by means of phosphoric anhydride; and a doubt may remain whether, on one hand, the removal of aqueous vapour is sufficiently complete, and on the other, whether some new impurity may not be introduced. I thought that it would be interesting to weigh hydrogen dried in an entirely different manner, and this I have recently been able to effect with the aid of liquid air, acting as a cooling agent, supplied by the kindness of Prof. Dewar from the Royal Institution. The operations of filling and weighing were carried out in the country as hitherto. I ought, perhaps, to explain that the object was not so much to make a new determination of the highest possible accuracy, as to test whether any serious error could be involved in the use of phosphoric anhydride, such as might explain the departure of the ratio of densities of oxygen and hydrogen from that of 16 : 1. I may say at once that the result was negative.

Each supply consisted of about six litres of the liquid, contained in two large vacuum-jacketed vessels of Prof. Dewar's design, and it sufficed for two fillings with hydrogen at an interval of two days. The intermediate day was devoted to a weighing of the globe *empty*. There were four fillings in all, but one proved to be abortive owing to a discrepancy in the weights when the globe was empty, before and after the filling. The gas was exposed to the action of the liquid air during its passage in a slow stream of about half a litre per hour through a tube of thin glass.

I have said that the result was negative. In point of fact the actual weights found were $\frac{1}{10}$ to $\frac{2}{10}$ milligrams *heavier* than in the case of hydrogen dried by phosphoric anhydride. But I